

Commercial Space Division Overview and Status

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Division Director

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Agenda



- Commercial Crew Program (CCP)
 - CCP (*to be covered in detail in next session*)
 - Suborbital Crew Project
- Commercial LEO Development Program
 - ISS Transition and Retirement
 - Commercial Destinations Free-Flyer
 - Commercial Destination on ISS
 - Private Astronaut Missions
 - Collaborations for Commercial Space Capabilities
- ISS National Lab/CASIS (*transferred back to ISS Division in mid-2021*)
- How Can NAC Help?

Commercial Crew Program

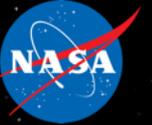
2021 CCP Highlights



- Successfully returned Crew-1, launched and landed Crew-2, and launched Crew-3, and docked to ISS for six-month increments
- Crew-2 Dragon broke the U.S. record for the longest human spaceflight mission (167 days; previous record of 84 days held by Skylab 4)
- Successfully executed two Dragon port relocations on-orbit
- Completed initial re-use assessments and flights for both Dragon spacecraft and Falcon 9 launch vehicle
- Performed both direct and indirect crew handovers, and the Crew-2 Dragon implemented an ISS fly-around prior to reentry



CCP-Enabled Space Travelers



Bob and Doug
Demo-2



Yulia Peresild, Klim Shipenko
Soyuz MS-19



Jared Isaacman, Hayley Arceneaux,
Sian Proctor, Christopher Sembroski
Inspiration4



Yusaku Maezawa, Yozo Hirano
Soyuz MS-20



Michael L-A, Larry Connor
Mark Pathy, Eytan Stibbe
Axiom-1



Mike, Victor,
Soichi, Shannon
Crew-1



Shane, Megan,
Akihiko, Thomas
Crew-2



Raja, Thomas,
Matthias, Kayla
Crew-3



Robert, Jessica
Kjell, Samantha
Crew-4



Suborbital Crew Project (SubC)

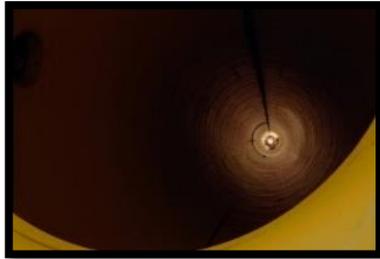
SubC Overview – Why Do it?



ISS
Days, Months, Years
of Microgravity



Parabolic Flight
~20 Seconds of
Microgravity



Drop Towers
Several Seconds of
Microgravity



Increasing Duration, Complexity, Cost, Lifecycle

SubC Overview – Why Do it?



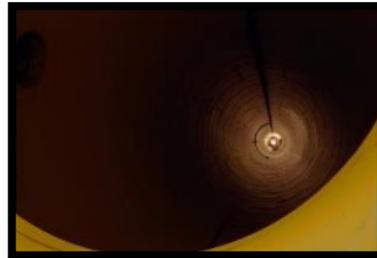
ISS
Days, Months, Years
of Microgravity



Suborbital Vehicles
Several Minutes of
Microgravity



Parabolic Flight
~20 Seconds of
Microgravity



Drop Towers
Several Seconds of
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Current Suborbital Capabilities

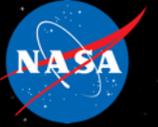


- Multiple commercial, FAA-licensed suborbital commercial providers
 - Systems completed significant flight test campaigns and are currently operational (as of 6/2021)
 - Developed entirely by private industry (i.e., without NASA technical or financial assistance)
- NASA is expected to one of many customers
 - Majority of customers are expected to be tourism customers, public sector researchers, and international government participants
 - Hundreds of customers have already reserved tickets
 - Academia expected to fly under “informed consent” via Flight Opportunities Program

NASA needs to find the sweet spot in process that:

- Recognizes the suborbital industry’s flight history and significant strides toward safety
- Enables a potential path for NASA risk acceptance

Building the Foundation (in work)



Phase 0

Building the Foundation

- Understand System Architecture and Vehicle Designs
- Approach to Standards in Shaping Designs
- Understanding Flight Test Strategy and Data Collected

(On Going)

Blue Origin

- KSC (Focal)
- JSC
- NESC

Virgin Galactic

- AFRC (Focal)
- KSC
- JSC
- NESC

Review Teams

On-going interchanges with Commercial Providers to build foundational understanding of systems, approaches, and values

- Technical Interchange Meetings completed with Blue Origin and Virgin Galactic
- Weekly Commercial Provider tag-ups give continued clarity toward data products and build trust
- Data reviews are on-going (e.g., System Overviews, Safety and Risk Analysis, Verification Plan, Informed Consent Approach, etc.)
- Agency and SubC leadership attended Blue Origin launch and performed a site review

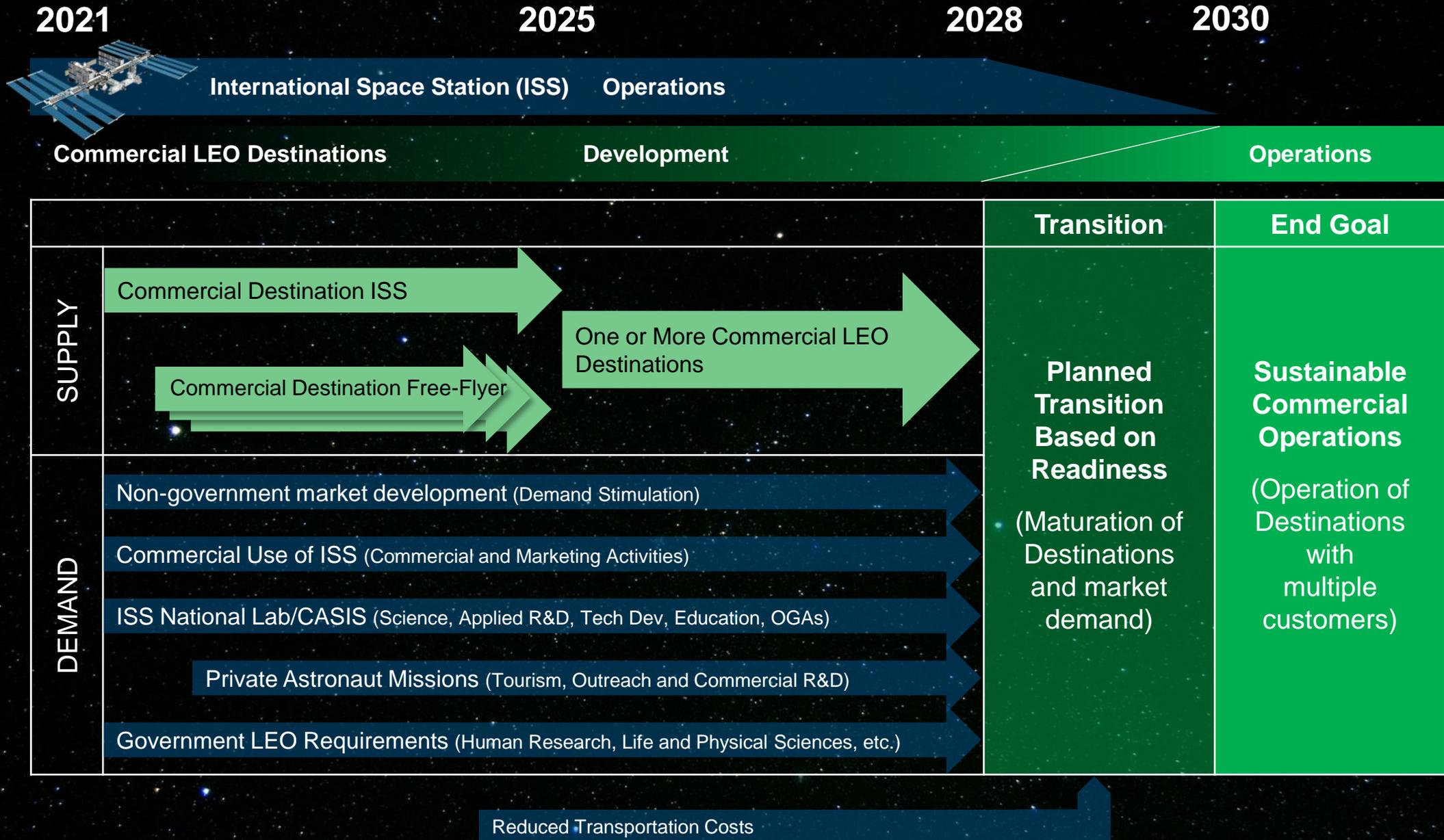
SubC Next Steps



- Focus for FY2022:
 - Continue refining the system qualification process.
 - Identify, characterize, and quantify NASA demand for commercial suborbital transportation services.
 - Coordinate with other government agencies (OGAs), particularly the Department of Defense, to determine and integrate demand for commercial suborbital capabilities from the OGAs into NASA's planning.
 - Coordinate with CASIS and identify potential areas of collaboration that would benefit the SubC office and CASIS.
 - Work with the Flight Opportunities Program (FOP) to identify synergies in procurements with a potential to incorporate SubC requirements into the next round of FOP contracts, expected to be in place in early-to-mid 2023.

Commercial LEO Development Program

Plan for ISS Transition to Commercial LEO Destinations



Why Do Commercial LEO Destinations?



- Provide continuous human access to space 
- Enable NASA science and research in LEO 
- Maintain our international partnerships 
- Save the Agency \$1.5B annually 
- Free up personnel resources for Artemis 

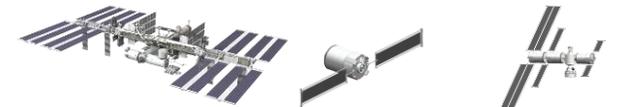
- Change the way we do human spaceflight in low Earth orbit 



How Will We Save Money?



- If NASA is one of many customers, then the cost savings will be obvious as the Commercial Provider(s) will be able to amortize their operating costs over multiple customers. NASA will not be footing the entire bill.
- Even in a scenario where NASA is the majority/exclusive customer, there are many reasons to believe that buying services from Commercial Providers will be significantly cheaper than operating/maintaining the ISS.
 - The ISS is the size of a football field. A Commercial LEO Destination will be smaller (see graphic).
 - NASA's ongoing requirements of at least 2 crew members on-orbit and the ability to perform approximately 200 investigations annually is significantly less than the current capability of the ISS.
 - Parts of the ISS are 20 years old. A Commercial LEO Destination will be brand new and will likely be designed with minimal maintenance requirements.
 - Every design and workforce decision made by a Commercial LEO Destination Provider will be driven by the need to be cost effective.
 - Experience with commercial companies has shown their ability to develop more streamlined and flexible processes and operations which results in cost savings.



	ISS	Free-Flyer	Small Station
	Living and working space larger than a six-bedroom house	Evolved module; Serviced by crew visits	Permanent crew; station conops
Power	~120 kW	25 kW	25-90 kW
Mass	400+ mt	18 mt	70 mt
Volume	930 m3	~40 m3	40-150 m3
Rack Volume	>100	12	42
Crew	6/0	2/1	2-3/2
EVA	Yes	No	Yes
Robotics	Yes	If needed	Yes
Ext. Payloads	Yes	Optional	Yes

Excerpt from one of the 2018 Industry Studies

Commercial Destination Free-Flyers



Company: **Nanoracks**, with Lockheed Martin and Voyager Space

Award: \$160M

Overview: Starlab – large inflatable habitat and a metallic docking node, power and propulsion element, and external robotic arm.

Description:

Four main operational departments: a biology lab, plant habitation lab, physical science and materials research lab, and an open workbench area.

Provide approximately 1/3 of ISS's habitable volume.

Achieve a CDR-level of maturity.



Company: **Northrop Grumman**, with Dynetics

Award: \$125.6M

Overview: Three integrated metallic pressure vessels initially, with 3 docking ports.

Description:

Habitat Modules derived from Habitation and Logistics Outpost (HALO) and Cygnus structures.

Service Module evolved from the Cygnus cargo vehicle, with a larger structure and increased propellant capacity.

Modules are supplemented with Cygnus designed for long-term stays.

Provides for multiple internal and external payloads.

Achieve a PDR-level of maturity.



Company: **Blue Origin**, with Sierra Space

Award: \$130M

Overview: Orbital Reef – provides zoned utilization, large volume and hatchways, highly automated operations, and assembly without spacewalks.

Description:

Microgravity research laboratory; experiment airlock; exposed payload locations; external robots; and extravehicular activity capabilities.

Provide approximately 90% of ISS's habitable volume.

Achieve a Critical-Design-Review (CDR)-level of maturity.

Commercial Destination on ISS

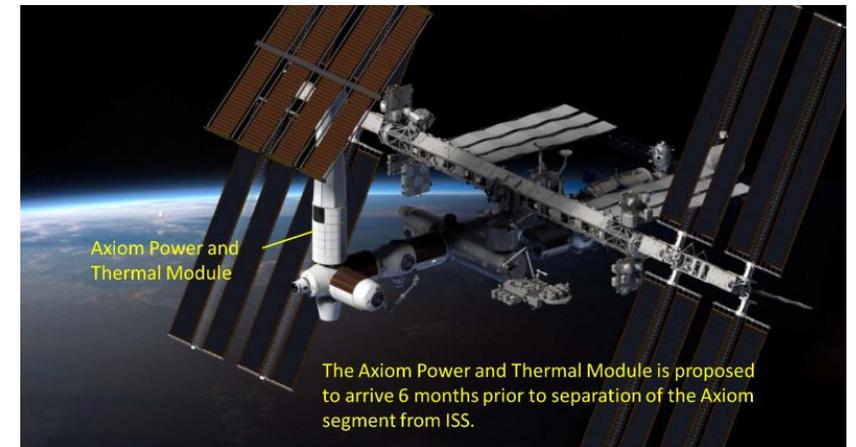
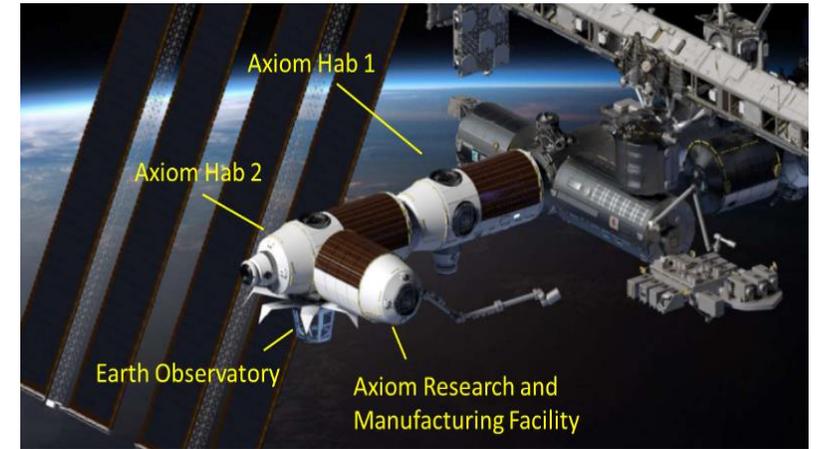


- **Project Status:**

- Axiom completed their System Requirements Review and Preliminary Design Review for the first two modules in Sept 2021.
- Long lead items for first two modules are in production and Axiom working towards critical design for primary structures.
- Next Task Order is under negotiation.

- **Near Term Forward Work:**

- CDR for the first two modules is currently targeted Summer 2022
- Axiom launch schedule has the first module arriving on ISS late 2024 and the final module required for independent free flyer capability in late 2028.



Private Astronaut Missions (PAMs)

- Private Astronaut Missions are commercial missions (no NASA personnel) to the ISS with full responsibility and liability resting on the Commercial Provider for mission success and crew safety (except when docked to ISS).
- NASA responsibility is solely based on protecting the ISS and ISS crew and providing limited services to enable the PAM.
- NASA enabling up to two short-duration PAMs to ISS per year.

- Axiom Space selected for first PAM (Ax-1)
 - Targeted for February 28, 2022.
 - 10 days total mission duration, using a Falcon 9/Dragon.
 - Crew conducting research, outreach and technology demos.



Ax-1 Prime Crew

- Axiom Space recently selected for PAM-2 targeted for late 2022/early 2023. NASA did not make a PAM-3 selection at this time.

Collaborations for Commercial Space Capabilities



- [Final Frontier Design](#) - Development of a new commercial Launch Escape/IVA suit. Recently completed rapid depressurization environment testing of a full-size escape suit at MSFC. On January 6, 2022, company was acquired by Paragon.
- [Northrop Grumman](#) - Development of a commercial Mission Extension Vehicle for servicing satellites in-orbit to provide propulsion and attitude control to extend their lives. Currently engaged in a collaborative electric thruster development effort with GRC.
- [SpaceX](#) - Development of a commercial Mars Starship transportation system. Assisted with wind tunnel and material testing, aerodynamic and aerothermal design, and technical advice for Mars mission design.
- [ULA](#) - Development of the new Vulcan commercial launch vehicle. Commenced LaRC trade study of using Hypersonic Inflatable Aerodynamic Decelerator technology to recover launch vehicle elements.
- A new competition is anticipated in FY22 for new no-exchange-of-funds SAAs focused on encouraging the development of U.S. commercial capabilities in LEO.

How Can NAC Help?

Commercial Human Spaceflight



- The Space Act directs NASA to seek and encourage, to the maximum extent possible, the fullest commercial use of space.
- NASA has been actively enabling US Commercial Human Spaceflight since 2005, through Commercial Orbital Transportation Services (COTS), Commercial Crew, Private Astronaut Missions and private citizen spaceflight missions (e.g., Inspiration 4).
- For each of these missions, there has been some level of NASA-support.

A fully commercial human spaceflight industry must be capable of being independent of NASA support.

Commercial Human Spaceflight – cont.



- Commercial human spaceflight is happening now
- USG needs to address current and long-lead challenges to enable a seamless transition to purely commercial human spaceflight in the U.S.
- Addressing these challenges is essential to enabling U.S. commercial space activities to scale to their full potential and ensure Article VI responsibilities under the Outer Space Treaty continue to be met in the future

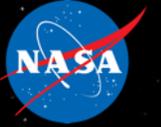
Request NAC support to engage the National Space policy community to lead an interagency effort to address the roadblocks to fully enabling commercial human spaceflight





QUESTIONS

Commercial Human Spaceflight Concerns



<u>What's Needed</u>	<u>Mission phase</u>	<u>Concern</u>
Human Safety Requirements	<i>Pre-Launch & Launch</i>	No commercial industries standards & processes for Human Space Flight (occupant safety)
		No clear agency reviewing occupant safety requirements compliance
		Lack of Government Certification
		Use of CCP requirements in 1130, 1120 and 1150 may be too restrictive for pure commercial missions.
Eliminate redundancy and address gaps in Ground Safety and Public Safety requirements	<i>Pre-launch & Launch</i>	Overlapping oversights at federal ranges/NASA sites for ground safety (pre-launch) and public safety (launch)
Export Control	<i>Pre-Launch & Launch</i>	Assess potential concerns associated with commercial vehicles used for both Government and private missions
Proprietary Data Release	<i>Pre-Launch & Launch</i>	Assess potential concerns associated with commercial vehicles used for both Government and private missions
Technical Expertise/Service only exists within the government or with few commercial providers	<i>Pre-Launch & Launch</i>	Flight safety analysis expertise is limited to a few entities
		Emergency Rescue – DoD Search and Rescue services not available to commercial mission
		Continuous Communication - Limited availability for Commercial Providers to utilize heritage HSF communication systems (i.e., S-band & TDRSS)
		Non-Continuous Communication – Use of commercial ground stations/frequencies (KA, L-Band, X-band) do not provide continuous communications due to no ability to prioritize coverage in public spectrum ranges.